

## PATENT COOPERATION TREATY

PCT

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY **MARGER JOHNSON**  
(Chapter II of the Patent Cooperation Treaty) **ET AL**

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	<b>FOR FURTHER ACTION</b> See Form PCT/IPEA/416	
International application No. <b>PCT/KR2004/000729</b>	International filing date(day/month/year) <b>30 MARCH 2004 (30.03.2004)</b>	Priority date (day/month/year) 21 JULY 2003 (21.07.2003)
International Patent Classification (IPC) or national classification and IPC  <b>IPC7 H01L 27/146, H01L 31/10</b>		
Applicant  <b>OPTOMECHA CO., LTD. et al</b>		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
- a. ☒ (sent to the applicant and to the International Bureau) a total of 17 sheets, as follows:
- ☒ sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
- ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
- b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) \_\_\_\_\_ containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:
- ☒ Box No. I Basis of the report
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability: citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand  <b>18 FEBRUARY 2005 (18.02.2005)</b>	Date of completion of this report  10 NOVEMBER 2005 (10.11.2005)
Name and mailing address of the IPEA KR  Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701 Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer  YOL Hwan Cheol Telephone No. 82-42-484-5743

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/KR2004/000729

## Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

- ☐ This report is based on translations from the original language into the following language \_\_\_\_\_ which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
  - ☐ publication of the international application (under Rule 12.4)
  - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

- ☐ the international application as originally filed/furnished
- ☒ the description:  
pages 1-4, 12, 16-17 \_\_\_\_\_ as originally filed/furnished  
pages\* 5-6, 6/1, 7-11, 13-15, 18 \_\_\_\_\_ received by this Authority on 19/05/2005  
pages\* 5-6, 6/1, 7-11, 13-15, 18 \_\_\_\_\_ received by this Authority on 13/10/2005
- ☒ the claims:  
pages \_\_\_\_\_ as originally filed/furnished  
pages\* \_\_\_\_\_ as amended (together with any statement) under Article 19  
pages\* 19-23 \_\_\_\_\_ received by this Authority on 19/05/2005  
pages\* 19-23 \_\_\_\_\_ received by this Authority on 13/10/2005
- ☒ the drawings:  
pages 1/16-16/16 \_\_\_\_\_ as originally filed/furnished  
pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_  
pages\* \_\_\_\_\_ received by this Authority on \_\_\_\_\_
- ☐ the sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. ☒ The amendments have resulted in the cancellation of:

- ☐ the description, pages \_\_\_\_\_
- ☒ the claims, Nos. 1-9, 16-18 \_\_\_\_\_
- ☐ the drawings, sheets \_\_\_\_\_
- ☐ the sequence listing (*specify*): \_\_\_\_\_
- ☐ any table(s) related to sequence listing (*specify*): \_\_\_\_\_

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages \_\_\_\_\_
- ☐ the claims, Nos. \_\_\_\_\_
- ☐ the drawings, sheets \_\_\_\_\_
- ☐ the sequence listing (*specify*): \_\_\_\_\_
- ☐ any table(s) related to sequence listing (*specify*): \_\_\_\_\_

\* If item 4 applies, some or all of those sheets may be marked "superseded."

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/KR2004/000729

**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

## 1. Statement

Novelty (N)	Claims	10-15	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	10-15	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	10-15	YES
	Claims	NONE	NO

## 2. Citations and explanations (Rule 70.7)

Reference is made to the following document:

D1: JP08-043605A

D2: US6033766B

Original claims 1-9, 16-18 of the present application were cancelled and claims 10-15 were amended. This report is basis on an amended application received by this Authority on 13/10/2005.

## I. Novelty and Inventive step

The claim 10 of the present invention relate to an image sensor including an array of optical path conversion elements, wherein incident surface of each optical path conversion element to have a tangent light incident slantingly on the peripheral area of the image sensor to be identical with that of light incident vertically on the central area of the image sensor to counterbalance the inclination angle of light incident on the peripheral area of the image sensor.

D1(JP08-043605A) relates to an optical device including a wedge shapes element having different tangent ling gradients values

D2(US6033766B) relates to a method of producing a high resolution expanded analog gray scale mask.

- continued -

## Supplemental Box

In case the space in any of the preceding boxes is not sufficient.  
Continuation of:

-continued from Box V

The combination of D1 and D2 discloses that the corresponding parts of the optical path conversion elements have different tangent line gradient values. However, compared with the claim 10 of the present invention, the combination of D1 and D2 does not disclose what shapes of those element are in quantitative terms. Thus the present claim 10 seems to be novel(Article 33(2) PCT) and involves an inventive step (Article 33(3) PCT). The present claims 11-15 also comply with Article 33(2) and 33(3) PCT, as they are dependent claims.

## II. Industrial applicability

The industrial applicability of the present claim 10-15 is self-evident in the sense of Article 33(4) PCT.

----- The end -----

filter layer of a substrate and is sensed by the photoelectric elements.

The present invention takes notice of radical reasons of problems of the conventional image sensor, and solves the problems to raise efficiency of the image sensor. The conventional methods stick to resultant phenomena rather than radical countermeasures, and thus rarely improve efficiency of the image sensor. However, the present invention can considerably improve efficiency of the image sensor.

For this, the present invention is based on two very simple principles.

The first principle can be obtained from consideration of problems of the conventional image sensor that efficiency is bad. The optical efficiency of the conventional image sensor is reduced because light is slantingly incident on micro lenses.

Accordingly, the present invention makes light incident on the micro lenses at a right angle, or makes the micro lenses themselves perform this function (aspheric micro lenses). It is very meaningful that light is incident at a right angle. It implies that light is incident at a right angle on the micro lenses of peripheral pixels of the image sensor as well as the micro lenses of central pixels.

The second principle relates to a way of embodying the first principle, namely a way for making light incident on the surface of the image sensor at a right angle. Here, the present invention uses the Snell's law, a refraction law for controlling refractions when light passes through the interface between different media, and also uses the reflection law.

An optical path of light is changed due to refraction or reflection. Here, let's presume that the optical path of light slantingly incident on the peripheral pixels of the image sensor is changed by a refraction or reflection element and then light is incident on the micro lenses at a right angle.

Because light is incident on the micro lenses at a right angle, an angle of light refracted or reflected by the refraction or reflection element can be regarded as a fixed value. Therefore, we can consider that an inclination angle of light incident on the refraction or reflection element and a gradient value of an incident surface of the refraction

or reflection element are mutually dependent variables.

That is, when the inclination angle of light is changed, the gradient value of the incident surface has to be changed, to keep refracted or reflected light parallel to an optical axis. It implies that the present invention can make refracted or reflected light  
5 parallel to the optical axis by using optical path conversion elements which have different tangent line gradients on the corresponding parts of the incident surfaces according to distances between the corresponding parts and the center of the image sensor.

The present invention originates from these very simple but important radical principles, which will later be explained in more detail with reference to Figs. 8 to 10  
10 and Figs. 14 to 16.

In order to achieve the above-described object of the invention, there is provided an image sensor comprising: a substrate in which an array of photoelectric elements is formed; and an array of optical path conversion elements for converting optical paths of incident light formed at a light incident side of the substrate so that  
15 the optical path converted light may be incident on the substrate, each optical path conversion element being formed to match with each photoelectric element, wherein an incident surface of each optical path conversion element has a tangent line gradient value to convert the optical path of light incident slantingly on a peripheral area of the image sensor at a larger inclination angle as the peripheral area is away  
20 from the center of the image sensor to be identical with the optical path of light incident vertically on a central area of the image sensor to counterbalance the inclination angle of light incident on the peripheral area of the image sensor, the tangent line gradient values of corresponding parts of the incident surfaces of the optical path conversion elements at an identical distance from the respective  
25 matching photoelectric elements being different from one another according to distances between the corresponding parts and the center of the image sensor.

Preferably, the optical path conversion elements are micro prisms or micro reflecting mirrors having different incident surface gradient values according to the distances from the center of the image sensor.

Here, the single image sensor can include both the micro prism type optical path conversion elements and the micro reflecting mirror type optical path conversion elements.

In addition, the single optical path conversion element can include  
5 combinations of a plurality of micro prisms.

The micro prism type optical path conversion elements and the flat surface micro reflecting mirror type optical path conversion elements convert the optical path of light to be parallel to the optical axis.

Preferably, the image sensor includes micro lenses, and the micro lenses are positioned in the optical path of light converted by the optical path conversion elements, for condensing light to the photoelectric elements.

5     Preferable, the optical path conversion elements are aspheric micro lenses or aspheric micro reflecting mirrors.

The single image sensor can include both the aspheric micro lens type optical path conversion elements and the aspheric micro reflecting mirror type optical path conversion elements.

10     Preferably, the optical path conversion elements are so positioned that the centers of the optical path conversion elements are offset from the centers of the photoelectric elements according to the distances from the center of the image sensor.

15     Preferably, when the single image sensor is divided into a plurality of regions according to the distances from its center, the optical path conversion elements in the same region have the identical tangent line gradient value on the corresponding parts of the incident surfaces, but the optical path conversion elements in the different regions have different tangent line gradient values on the corresponding parts of the incident surfaces according to the distances between the corresponding parts and the center of the image sensor.

20     According to another aspect of the invention, there is provided a method for fabricating an image sensor in which optical path conversion elements are formed according to a photolithography process using a gray scale mask, combinations of the photolithography process and a reactive ion etching process, or combinations of the photolithography process, the reactive ion etching process, and an UV-molding process.

25

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a basic structure of a conventional image sensor which does not have an array of micro lenses;

Fig. 2 illustrates a basic structure of a conventional image sensor including



an array of micro lenses;

Fig. 3 illustrates one example of a system using an image sensor;

Fig. 4 illustrates low optical efficiency of peripheral pixels of the image sensor of Fig. 2;

5 Fig. 5 illustrates another example of a conventional image sensor wherein micro lenses are arranged on different planes according to distances from the center of the image sensor;

Fig. 6 illustrates yet another example of a conventional image sensor wherein micro lenses of different sizes are arranged according to distances from the center  
10 of the image sensor;

Fig. 7 illustrates yet another example of a conventional image sensor wherein micro lenses are arranged in deviated positions from photoelectric elements according to distances from the center of the image sensor;

Fig. 8 is a concept view showing that a prism can vary an optical path of light;

15 Fig. 9 illustrates the refraction law of light, especially light passing through the prism of Fig. 8;

Fig. 10 illustrates relations between an inclination angle and a gradient value of an incident surface for making light refracted by the prism parallel to an optical axis;

20 Figs. 11a and 11b illustrate image sensors including an array of micro prisms as optical path conversion elements in accordance with one embodiment of the present invention, wherein Fig. 11a shows the image sensor including a single array of micro prisms, and Fig. 11b shows the image sensor including a double array of micro prisms;

25 Fig. 12 illustrates an image sensor including an array of micro prisms and an array of micro lenses as optical path conversion elements in accordance with another embodiment of the present invention;

Fig. 13 illustrates an image sensor including an array of aspheric micro lenses in accordance with yet another embodiment of the present invention;

Fig. 14 is a concept view showing that a reflecting mirror can vary an optical

path of light;

Fig. 15 illustrates the reflection law of light, especially light reflected by the reflecting mirror of Fig. 14;

Fig. 16 illustrates relations between an inclination angle and a gradient value  
5 of an incident surface for making light reflected by the reflecting mirror parallel to an optical axis;

Fig. 17 illustrates an image sensor including an array of micro reflecting mirrors as optical path conversion elements in accordance with yet another embodiment of the present invention;

10 Fig. 18 illustrates an image sensor including an array of micro reflecting mirrors and an array of micro lenses as optical path conversion elements in accordance with yet another embodiment of the present invention;

Fig. 19 illustrates an image sensor including an array of aspheric micro reflecting mirrors in accordance with yet another embodiment of the present  
15 invention;

Figs. 20a to 20c respectively illustrate processes for fabricating an image sensor in accordance with various embodiments of the present invention;

Figs. 21a and 21b illustrate simulation results for the image sensor including the array of micro lenses in Fig. 2, wherein Fig. 21a shows an optical path of light,  
20 and Fig. 21b shows distribution of light intensity in photoelectric element; and

Figs. 22a and 22b illustrate simulation results for the image sensor including the array of micro prisms and the array of micro lenses in Fig. 12, wherein Fig. 22a shows an optical path of light, and Fig. 22b shows distribution of light intensity in photoelectric element.

## BEST MODE FOR CARRYING OUT THE INVENTION

25 An image sensor and a method for fabricating the same in accordance with preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

Fig. 8 is a concept view showing that a prism 10 can vary an optical path of light.

As illustrated in Fig. 8, the micro prism 10 converts the optical path of light to be parallel to an optical axis in order to prevent reduction of optical efficiency due to light slantingly incident on peripheral pixels of an image sensor.

The relations between an inclination angle of light incident on the surface of the prism 10, an angle of refracted light and a gradient value of an incident surface of the prism 10 will now be explained with reference to Fig. 9.

Fig. 9 illustrates the refraction law of light, especially light passing through the prism 8 of Fig. 8.

Fig. 9 shows a refraction path of light when light is incident on an interface between different media having a gradient of ' $\alpha$ '. When it is presumed that an angle of incident light to a normal line of the interface is ' $\theta_1$ ', an angle of refracted light to the normal line of the interface is ' $\theta_2$ ', a refraction index of the medium in the incident side is ' $n_1$ ' and a refraction index of the medium in the refraction side is ' $n_2$ ', the Snell's law is represented by following formula (1):

$$n_1 \sin \theta_1 = n_2 \sin \theta_2 \quad \dots\dots\dots (1)$$

Here, when it is presumed that the gradient of the interface is ' $\alpha$ ', an inclination angle of incident light to the optical axis is ' $\phi_1$ ' and an angle of refracted light to the optical axis is ' $\phi_2$ ', and they are introduced to formula (1), we can obtain following formula (2):

$$\tan \alpha = \frac{n_1 \sin \phi_1 - n_2 \sin \phi_2}{n_1 \cos \phi_1 - n_2 \cos \phi_2} \quad \dots\dots\dots (2)$$

In case that light is vertically refracted ( $\phi_2=0$ ) through the surface of the prism 10, the gradient  $\alpha$  of the incident surface of the prism 10 is represented by following formula (3) with regard to the inclination angle  $\phi_1$  of incident light and the refraction

indexes  $n_1$  and  $n_2$  of the media:

$$\alpha = \tan^{-1} \left( \frac{n_1 \sin \phi_1}{n_1 \cos \phi_1 - n_2} \right) \dots \dots \dots (3)$$

Fig. 10 illustrates relations between the inclination angle and the gradient value of the incident surface for making light refracted by the prism 8 parallel to the optical axis.

Fig. 10 shows the gradient  $\alpha$  of the incident surface of the prism 10 according to the inclination angle  $\phi_1$  of light incident on the incident surface of the prism 10 for making refracted light parallel to the optical axis, when the refraction index of the medium in the incident side is '1' and the refraction index of the medium in the refraction side is '1.5'.

Here, two points must be noted.

First, as the inclination angle  $\phi_1$  increases, that is, in the peripheral pixels of the image sensor, the gradient of the incident surface of the prism 10 increases in the negative direction, which will later be explained with reference to Fig. 11a.

Second, when the refraction index of the prism 10 is larger than that of the medium in the incident side, the gradient of the incident surface of the prism 10 has a negative value, and reversely, when the refraction index of the prism 10 is smaller than that of the medium in the incident side, the gradient of the incident surface of the prism 10 has a positive value, which will later be explained with reference to Fig. 11b.

Figs. 11a and 11b illustrate image sensors including an array of micro prisms 10 as optical path conversion elements in accordance with one embodiment of the present invention. Here, Fig. 11a shows the image sensor including a single array of micro prisms 10, and Fig. 11b shows the image sensor including a double array of micro prisms 10a and 10b.

Figs. 11a and 11b show that the array of micro prisms 10 having different incident surface gradients can make light incident at different angles on each pixel refracted parallel to an optical axis.

lenses.

Fig. 13 illustrates the image sensor including the array of aspheric micro lenses 11 in accordance with yet another embodiment of the present invention.

As illustrated in Fig. 13, tangent lines to the corresponding parts of the incident surfaces have different gradients according to distances between the corresponding parts and the center of the image sensor, and thus aspheric micro lenses 11 in different shapes are arranged to convert optical paths of slantingly incident light and condense light to photoelectric elements 1. That is, the aspheric micro lens and aspheric micro reflecting mirror have different tangent line gradient values on individual parts of the incident surface of the same optical path conversion element to condense incident light to the photoelectric element. Therefore, the aspheric micro lenses 11 perform functions of micro prisms 10 as optical path conversion elements as well as functions of micro lenses 5 as condensers.

Differently from the micro prisms 10, tangent line gradients are different at each point on the incident surface of one aspheric micro lens 11. The tangent line gradients at each point can be calculated by formula (2).

Figs. 8 to 13 show that we can improve optical efficiency of the image sensor by using the refraction law. The reflection law has the same effects as discussed later.

Fig. 14 is a concept view showing that a reflecting mirror 12 can vary an optical path of light.

Relations between an inclination angle of light incident on the surface of the reflecting mirror 12, an angle of reflected light and a gradient value of an incident surface of the reflecting mirror 12 will now be described with reference to Fig. 15.

Fig. 15 illustrates the reflection law of light, especially light incident on the reflecting mirror 12 of Fig. 14.

Fig. 15 shows an angle of reflected light when light is incident on the incident surface having a gradient of  $\beta$ . When it is presumed that an angle of incident light to a normal line of the incident surface is ' $\theta_3$ ' and an angle of reflected light to a normal line of the incident surface is ' $\theta_4$ ', the reflection law is represented by formula (4):

$$\theta_3 = \theta_4 \dots\dots\dots (4)$$

Here, when it is presumed that the gradient of the incident surface is ' $\beta$ ', an inclination angle of incident light to an optical axis is ' $\phi_3$ ' and an angle of reflected light to the optical axis is ' $\phi_4$ ', and they are introduced to formula (4), we can obtain following formula (5):

5

$$\beta = 90^\circ + \frac{\phi_3 + \phi_4}{2} \dots\dots\dots (5)$$

The gradient  $\beta$  of the reflecting mirror 12 for making light reflected by the reflecting mirror 12 parallel to the optical axis ( $\phi_4=0$ ) is represented by following  
10 formula (6) with regard to the gradient  $\phi_3$  of incident light:

$$\beta = 90^\circ + \frac{\phi_3}{2} \dots\dots\dots (6)$$

Fig. 16 illustrates relations between the inclination angle and the gradient  
15 value of the incident surface for making light reflected by the reflecting mirror 12 parallel to the optical axis.

Here, as the inclination angle increases, that is, in the peripheral pixels of the image sensor, the gradient of the incident surface of the reflecting mirror 12 increases, which will later be explained with reference to Fig. 17.

20 Fig. 17 illustrates an image sensor including an array of micro reflecting mirrors 12 as optical path conversion elements in accordance with yet another embodiment of the present invention.

The method of Fig. 17 reflects light incident at different angles on each pixel to be parallel to an optical axis by using the array of micro reflecting mirrors 12  
25 having different incident surface gradients. This method equalizes angles of light incident on photoelectric elements 1, and thus equalizes amounts of light sensed in each position of the image sensor.

Fig. 18 illustrates an image sensor including an array of micro reflecting

mirrors 12 and an array of micro lenses 5 as optical path conversion elements in accordance with yet another embodiment of the present invention.

As shown in Fig. 18, the image sensor uses both the array of micro reflecting mirrors 12 and the array of micro lenses 5. Here, the array of micro reflecting mirrors 12 convert an optical path of light to be parallel to an optical axis, and the array of micro lenses 5 condense light to photoelectric elements 1. Accordingly, the method of Fig. 18 more efficiently senses light than the method of Fig. 17, and equalizes amounts of light sensed in each position.

Fig. 19 illustrates an image sensor including an array of aspheric micro reflecting mirrors 13 in accordance with yet another embodiment of the present invention.

Referring to Fig. 19, tangent lines to the corresponding parts of incident surfaces have different gradients according to angles of light incident on the surface of the image sensor, namely distances of each pixel from the center of the image sensor, and thus aspheric micro reflecting mirrors 13 in different shapes are arranged to convert optical paths of slantingly-incident light and condense light to photoelectric elements 1. That is, the aspheric micro reflecting mirrors 13 perform the functions of the optical path conversion element as well as the condenser.

Differently from the flat surface micro reflecting mirrors 12, tangent line gradients are different at each point on the incident surface of one aspheric micro reflecting mirror 13. The tangent line gradients at each point can be calculated by formula (5).

As discussed earlier, the image sensor of the invention includes optical path conversion elements having different tangent line gradients on the corresponding parts of incident surfaces according to distances between the corresponding parts and the center of the image sensor. It is therefore required to fabricate fine structures having various tangent line gradients. It is very difficult to fabricate the fine structures according to a single process using a conventional MEMS process.

However, as shown in Figs. 20a to 20c, the fine structures having various

photodiodes is  $8\mu\text{m}$ .

Referring to Figs. 21a and 21b, if the array of micro prisms 10 does not exist and the inclination angle of light is  $0$  or  $10^\circ$ , the focus is formed on the photodiodes and thus the photodiodes can sense light. However, if the array of micro prisms 10  
5 does not exist and the inclination angle of light is  $20$  or  $30^\circ$ , the photodiodes cannot sense light.

Even if the inclination angle of light is  $10^\circ$ , the photodiodes having small area cannot sense a lot of light.

Figs. 22a and 22b illustrate simulation results for the image sensor including  
10 the array of micro prisms 10 and the array of micro lenses 5 in Fig. 12. Here, Fig. 22a shows the optical path of light, and Fig. 22b shows distribution of light intensity in the photoelectric element 1.

As shown in Figs. 22a and 22b, if the array of micro prisms 10 and the array of micro lenses 5 exist and an inclination angle of light is  $0$ ,  $10$ ,  $20$  or  $30^\circ$ , the focus  
15 is formed on the photodiodes and thus the photodiodes can sense light.

On the Basis of an amount of light sensed by the photodiodes at an inclination angle of  $0^\circ$ , when the micro prism arrangements 10 do not exist and exist, condensation efficiency is  $92\%$  and  $93\%$  respectively at an inclination angle of  $10^\circ$ ;  $0\%$  and  $90\%$  respectively at an inclination angle of  $20^\circ$ ; and  $0\%$  and  $76\%$   
20 respectively at an inclination angle of  $30^\circ$ .

Accordingly, even when the inclination angle of light incident on the image sensor is large, the micro prisms 10 can make the photodiodes of the image sensor efficiently sense light.

Although the preferred embodiments of the present invention have been  
25 described, it is understood that the present invention should not be limited to these preferred embodiments but various changes and modifications can be made by one skilled in the art within the spirit and scope of the present invention as hereinafter claimed.